Atmospheric Physics I

2b. Determine the variables associated with fundamental physical concepts.

Scientific measurements

- Fundamental Quantities – What you are measuring.
  - Mass (M) – the amount of matter in an object (not the same as weight which is defined later in this unit.
  - Length (L) – a measurement of distance
  - Time (T) – a period over which an action takes place.

Scientific measurements

- Fundamental Units
  - Mass – kilogram [kg]
  - Length – meter [m]
  - Time – second [s]

Scientific measurements

- Scientific notation – standard method of expressing numbers much greater than or much less than one.
  - Express 7823 in scientific notation
  - Express 0.007823 in scientific notation

Scientific measurements

- Unit prefixes – used to distinguish between very large and very small values of fundamental quantities.
  - Prefixes – placed ahead of the BASE UNIT (grams, meters or seconds)
  - Allow magnitudes to be expressed in smaller numbers. (i.e. 100 kilometers instead of 100,000 meters)

PREFIXES COMMONLY USED IN WEATHER

PREFIX	#OF BASE UNITS	
KILO (k)	1000	(10_3)
HECTO (h)	100	(10_2)
DECA (da)	10	(10_1)
BASE UNIT	1	(10_0)
	1/10	(10_{-1})
CENTI (cm)	1/100	(10_{-2})
MILLI (mm)	1/1000	(10_{-3})
MICRO (u)	1/000000	(10_{-6})

Scientific measurements

- Sample meteorological variables
  - Wind Speed (Horizontal) – m/s
  - Wind Speed (Vertical) – cm/s
  - Distance – m, dam, km

Scientific measurements

- Unit conversions
  - Converting from a large prefix to a smaller prefix. Example 540 dam to dm.
    - Find the prefix on Table 1.
    - Count the number of places you have to move to get to the new prefix. Example: to get to dm, you move 2 places down, or 10^2. This is the conversion factor. It takes 10^2 dm to make 1 dam.
    - Multiply conversion factor by value of prefixed units (540 dam x 10^2 dm/dam).
    - Label the answer with new units (54,000 dm).

Scientific measurements

- Unit conversions
  - Converting from a smaller prefix to a larger prefix. Example: Convert 5400 m to dam.
    - Find the prefix on Table 1.
    - Count the number of places you have to move to get to the new prefix. Example: to get to dam, you have to move one place up, or 10^{-1}. This is the conversion factor. (It takes 10^{-1} dam to equal 1 dm.)
    - Multiply conversion factor by value of prefixed units (5400m x 10^{-1} dam/m).
    - Label the answer with the new units (540 dam).

Scientific measurements

- Significant digits – an important concept in weather.
  - Some common reportable values are: to the nearest:
    - Wind/propagation speeds: 5 kts
    - Pressure on a surface plot: 1/10 (.1) mb
    - Pressure on upper air plots: whole mb
    - Heights on upper air plots: decameter (dam)
    - Temperature on Skew-T: 1/10 (.1) degree
    - All other temperatures: whole degree
    - Relative humidity: whole percent

Scientific measurements

- Significant digits – an important concept in weather.
  - Use reportable values in weather. Example: Find the average temperature for a day when the maximum temperature was 55ºF. and the minimum temperature was 40ºF.

Scientific measurements

- Significant digits – an important concept in weather.
  - For other calculations, don't carry out decimals any further than the lowest decimal place in the original numbers. Example: find the answer to the following calculation: 34.3 x 22

Atmospheric Scales

- Provide a system to classify weather phenomenon of varying sizes.
- Values given are “typical” size and duration of each scale.

Atmospheric Scales

- Macroscale (planetary or global) (i.e. larger than North America)
  - Size: Approximately 10,000 km or larger.
  - Time scale: several days to several weeks to months
  - Example: Jet axis, circumpolar vortex, general circulation

Atmospheric Scales

- Synoptic scale (weather map scale)
  - Size: Approximately 1000 km
  - Time scale: tens of hours to several days or a week
  - Examples: Frontal systems, tropical cyclones, jet streaks

Atmospheric Scales

- Mesoscale
  - Size: Approximately 10 to 100 km (1nm = 1.85 km)
  - Time scale: tens of minutes to several hours
  - Examples: thunderstorms, sea breezes

Atmospheric Scales

- Microscale
  - Size: Approximately 1 km or less
  - Time scale: a few seconds to a few minutes
  - Examples: turbulent flow (updrafts and downdrafts)

Variable Relationships

- Direct proportion
  - When two variables are in direct proportion, an increase or decrease in one variable results in the same relative increase or decrease in a second variable.
  - $x \propto y$: if x increases, y increases. If x decreases, y decreases

Variable Relationships

- Inverse proportion
  - When one variable increases, a second variable decreases in the same ratio.
  - $x \propto 1/y$: If x decreases, y increases. If x decreases, y increases.

Variable Relationships

- Determining the relationship of variables
  - Compare only 2 variables at a time.
  - Hold all the rest constant (place a dot over all the other variables)

Variable Relationships

- Evaluate the dependence of the two variables by increasing the value of one and determine the effect on the other. Examples:
  - Determine the relationship between x and z in $x = \frac{y}{z}$
    - Increasing x will cause z to increase.
    - x and z are directly proportional

Variable Relationships

- Determine the relationship between y and z in

$$x = y\,z$$

  - Increasing y will cause z to decrease in order to keep x constant.
  - y and z are inversely proportional.

Variable Relationships

- Determine the relationship between x and z in $\frac{x}{y} = \frac{x}{z}$
  Increasing x will cause z to increase in order to keep y constant.
  - x and z are directly proportional.

- Determine the relationship between y and z in $y = \frac{x}{z}$
  - Increasing y will cause z to decrease in order to keep x constant.
  - Y and z are inversely proportional

Coordinate Systems

- Method for identifying the exact location of points in space and plotting vectors to scale.
- Cartesian coordinates (x, y, z) – a three dimensional system
  - The basis for other coordinate systems
  - Coordinates are expressed in terms of components along each of three perpendicular axes, which intersect at the origin, or center of the system. Remember…this system is used in three dimension (3D).

Coordinate Systems

- Cartesian coordinates (cont).
  - All axes are perpendicular intersecting at 90-degree angles at the origin.
  - We use 3 basic types of coordinates to graphically represent vectors

Coordinate Systems

- Navigational system (north-south, east-west) a two dimensional system. Does not take into account vertical movement.
  - Describes motion in terms of the direction ***towards*** which it is going.
  - Magnitudes are indicated by length of the arrows.
  - Directions are indicated by orientation of an arrow and measured in degrees clockwise from north.

Coordinate Systems

- Navigational system (cont)
  - The suffix “-ward” indicates that vectors in this system are oriented in the direction ***toward*** which the force is being applied.
  - Used for vector calculations (covered in the next chapter)

Coordinate Systems

- Meteorological System – a two dimensional system which does not take into account vertical motion.
  - Describes motion in terms of the direction ***from*** which it comes.
  - Magnitudes are indicated by barbs.
  - Directions are indicated by orientation of shafts measured in degrees clockwise from north.

Coordinate Systems

- Meteorological System (cont)
  - The suffix “-ly” indicates that vectors in this system are oriented in the direction ***from*** which the force or motion is being applied.
  - Used to report winds.

Coordinate Systems

- Natural coordinate system (s, n, z) – a three dimensional system.
  - Describes motion in terms of direction ***towards*** which it is going.
  - S-axis oriented parallel to the direction of the flow at the origin, with +s oriented downstream and –s oriented upstream.
  - N-axis oriented normal (perpendicular) to the flow, with +n oriented to the left of the flow, and the –n oriented to the right of the flow.

Coordinate Systems

- Natural coordinate system (cont)
  - Z-axis oriented vertically, with +z oriented upwards and –z oriented downwards.
  - System moves with the wind flow.
    - Orientation of the axes is not fixed to the compass as the Nav and Met systems are.
    - The origin or center of the system is the moving air parcel through the flow.
  - ***Very useful in understanding the processes involved in atmospheric motion. We will be using this system during our discussion of the balance of forces acting on the atmosphere.***

- APPLICATION: Assign review exercise in WB-100.
- EVALUATION: Administer and evaluate appraisal 102b.